Application for Finding of Reasonable Diligence and to Make Conditional Rights Absolute for the Fryingpan-Arkansas Project
Southeastern Colorado Water Conservancy District

Case No. 2018CW3063

Water Division 5

Draft Engineering Report

Prepared for:

Southeastern Colorado Water Conservancy District

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Water Division 5

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1.0 INTRODUCTION

The Southeastern Colorado Water Conservancy District (SECWCD) filed an application for reasonable diligence and to make conditional rights absolute that are decreed as part of the Fryingpan-Arkansas Project (Project) in Division 5. The Project water rights described in the Case No. 2018CW3063 application were originally decreed to SECWCD in Case No. 4613, August 3, 1959 (Garfield County District Court). The decree was modified to reflect as-built conditions and approved for finding of diligence in Case No. W-829-76, November 27, 1979. The conditional rights were approved for findings of diligence and/or issued absolute and partial absolute decrees in Case Nos. 80CW267, 84CW195, 88CW245, 95CW53, 01CW265, and 09CW40.

SECWCD entered into stipulations on its last diligence application in Case No. 09CW40 with the U.S. Forest Service and Trout Unlimited. The stipulations outlined several actions that SECWCD agreed to take to support the current diligence application, including undertaking a study to show the extent to which historical Project diversions have fallen short of the authorized yield, the expected yield of the remaining conditional rights, and alternatives for realizing the authorized yield of the Project. In addition, SECWCD agreed to meet with Reclamation and the U.S. Forest Service to discuss these diligence efforts prior to filing the application.

This engineering report supports the request for finding of reasonable diligence and to make conditional rights absolute. In addition, this engineering report describes the analyses undertaken to meet the action items outlined in the 09CW40 stipulations. This report details the following analyses:

1. Review of historical Project yield from existing facilities.
2. Review of measured diversions over the diligence period to determine conditional water rights that have been diverted and, therefore, can be decreed absolute.
3. Analysis of yield of the absolute and conditional water rights based on legal and physical ability to divert at the decreed locations.
4. Investigation of opportunities to develop conditional water rights.
5. Analysis of options to increase yield through current Project facilities.

Opinions based on the analyses in support of the application for reasonable diligence and to make conditional rights absolute are provided in **Section 9**.

1.1 Fryingpan-Arkansas Project West Slope Facility Overview

The Division 5 water rights and facilities were features of the original Project design and included diverting native water from tributaries to the Roaring Fork River and conveying the water through a series of collection canals and tunnels for delivery through Boustead Tunnel to

the upper Arkansas River basin. The Project provides a supplemental source of water for beneficial uses within SECWCD boundaries. SECWCD and Reclamation deliver Project Water primarily for supplemental irrigation, municipal, and domestic uses.

Figure 1 provides a map showing the location of the absolute and conditional Project Water rights (Project Rights), existing west-slope Project facilities and associated capacities, and streamflow bypass requirements.

1.2 Project Need

The Project delivers transmountain water diverted from the Roaring Fork watershed and native Arkansas River water rights stored in Turquoise, Twin Lakes, and Pueblo Reservoirs for Project uses. The amount of water available for allocation is determined annually based on SECWCD's Project Water Allocation Principles, November 29, 1979, and Water Allocation Policy as amended April 19, 2013. The amount of Project Water available for allocation varies greatly from year-to-year. For example, in the dry year of 2002, less than 11,000 acre-feet was available and allocated to municipal and irrigation users. In the previous average year of 2001, over 60,000 acre-feet was allocated.

The use of Project Water as a supplemental source, coupled with limited allocations compared to need in many years, highlights that any additional water developed under the original Fryingpan-Arkansas Project Water rights can, and will, be put to beneficial use.

1.3 Definitions

Project. The Fryingpan-Arkansas Project, Colorado, as authorized by the Fryingpan-Arkansas Project Act of August 16, 1962.

Project Water Rights. The Fryingpan-Arkansas Project absolute and conditional water rights decreed as part of the Fryingpan-Arkansas Project for diversion from Roaring Fork River basin in Division 5, including the water rights listed in the 2018CW3063 proposed decree.

Existing Project Facilities. The series of diversions structures and tunnels constructed to divert and move Project Water from the Roaring Fork River basin to the Arkansas River Basin.

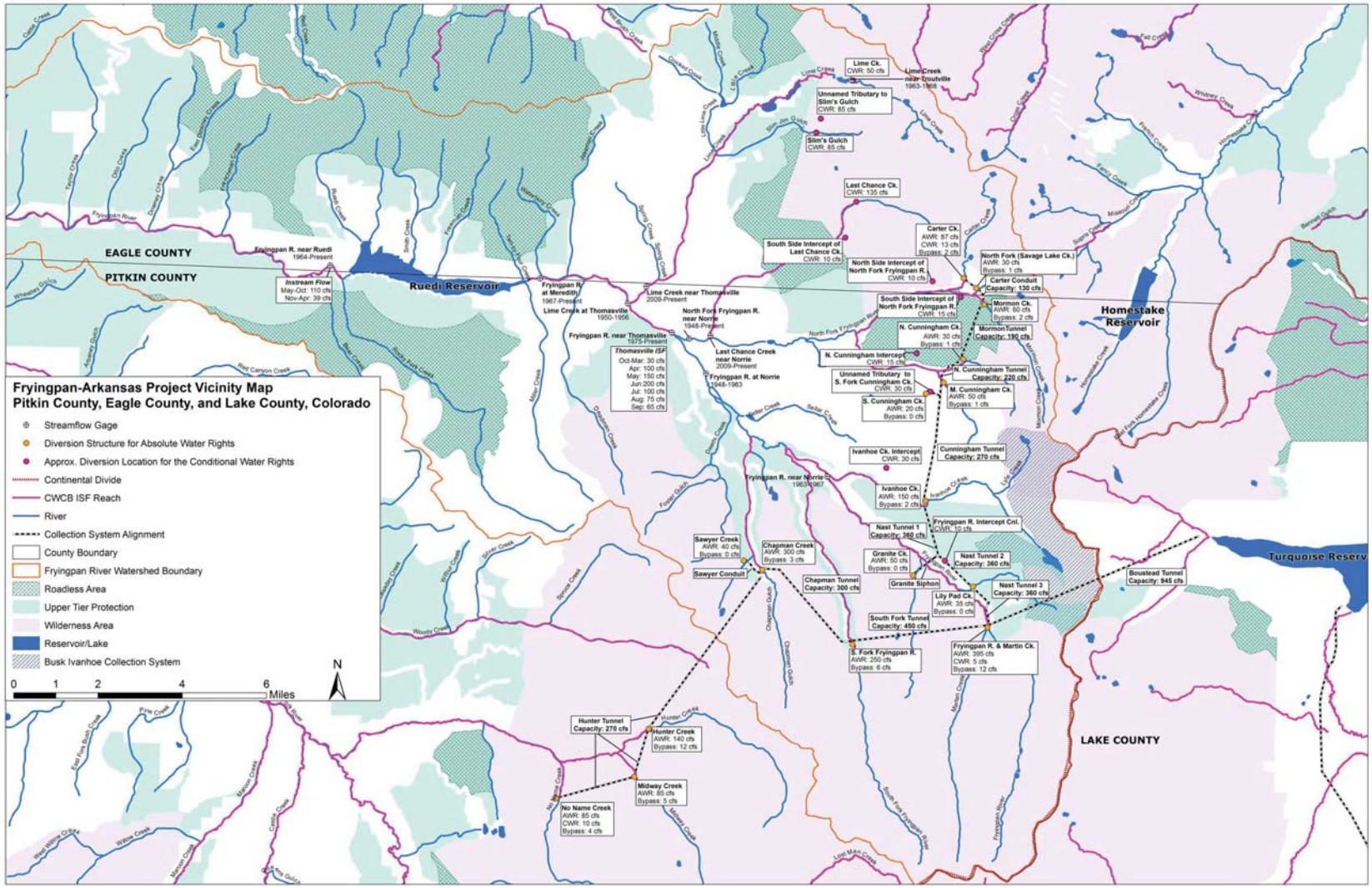

Figure 1 – Location Map

2.0 HISTORICAL PROJECT YIELD FROM EXISTING DIVERSIONS

The Project Operating Principles and subsequent decrees authorized diversions from the Roaring Fork tributaries totaling 2,352,800 acre-feet in any thirty-four consecutive year period. This corresponds to a 34-year running average of 69,200 acre-feet per year. In addition, Project diversions through Boustead Tunnel cannot exceed 120,000 acre-feet in any year. Per the Project Operating Principles, the 69,200 acre-feet running average annual limitation and 120,000 acre-feet annual limitations are exclusive of water diverted through Boustead Tunnel for the Twin Lakes Exchange or under the Busk-Ivanhoe decree.

The historical Project yield has fallen short of the authorized Project yield. Based on the Project diversions through Boustead Tunnel from the Annual Operating Plans accounting published by Reclamation and compiled for this analysis, the average annual yield from 1985 through 2017 was 51,560 acre-feet. This 31-year period is shorter than the 34-year period for determining average annual yield; this is because data from 1985 forward includes full use of the current Project facilities, and this data is believed to be more reliable than data prior to 1985, as confirmed through conversations with Reclamation staff. The shorter term average annual yield has been higher, averaging 59,800 acre-feet per year for the 2010 through 2017 period and 63,600 acre-feet per year for the 2013 through 2017 period – still short of the average annual 69,200 acre-feet contemplated Project yield. As discussed below, yield of the Project Water rights through the existing project facilities is expected to be greater with more optimized operations.

Figure 2 shows annual Project diversions through Boustead Tunnel. For information purposes, total annual diversions (Project and non-Project) through the Boustead Tunnel measured at the East Portal of the Tunnel (Gage 09077160, Charles H. Boustead Tunnel) gage are also shown. Project diversions through Boustead Tunnel from the Annual Operating Plan (AOP) accounting reports vary from the reported gaged flows at the East Portal of the Tunnel due to inclusion of diversions for Busk-Ivanhoe and Twin Lakes Exchange, seepage, and measurement accuracy limitations.

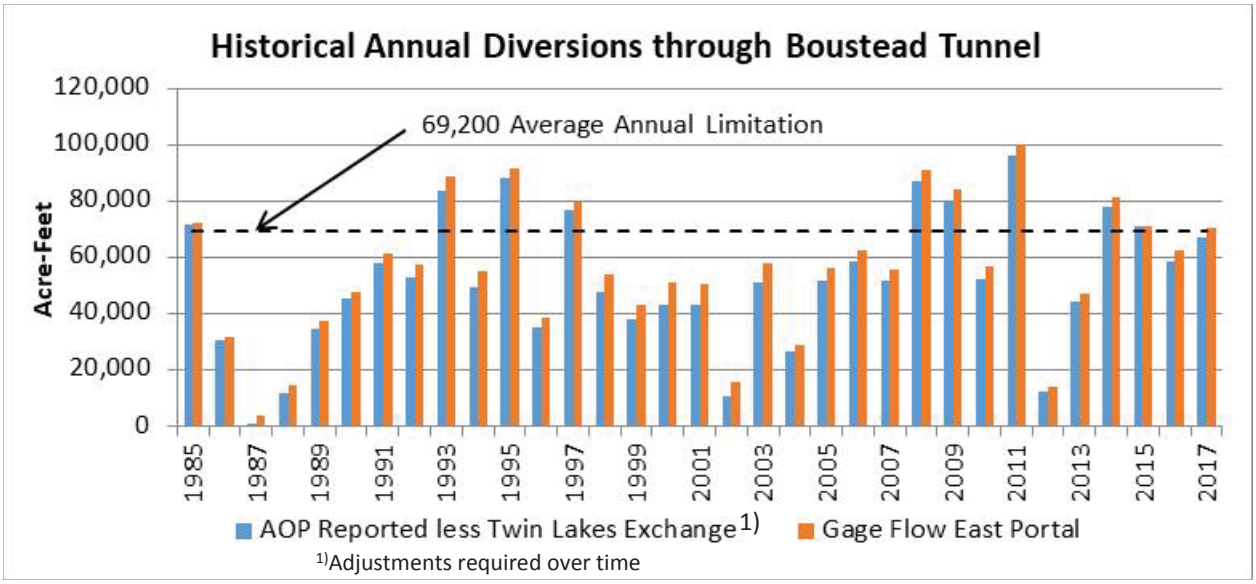

Figure 2 – Historical Annual Diversions through Boustead Tunnel

3.0 CONDITIONAL AND ABSOLUTE WATER RIGHTS

SECWCD Division 5 water rights can be grouped based on the collection system that conveys the water to Boustead Tunnel for delivery to the Arkansas River basin. **Table 1** lists absolute and conditional water rights and tributary sources that are components of the South Side Collection System; **Table 2** lists rights that are components of the North Side Collection System; and **Table 3** lists water rights that have been made absolute for Boustead Tunnel.

Table 1 – SECWCD Division 5 South Side Collection System Water Rights

Water Right	Original Decree	Diligence/ Absolute Decrees	Name of Tributary	Total Decreed Amount (cfs)	Conditional (cfs)
Hunter Creek Subsystem	C.A. No. 4613 Garfield County	84CW195 09CW40	No Name Creek and Unnamed Tributary	95 (85 previously decreed absolute)	10
			Midway (South Fork Hunter Creek and Unnamed Tributary)	85 (fully decreed absolute)	
			Hunter Creek	140 (fully decreed absolute)	
Chapman Gulch-Sawyer Lake Creek Subsystem	W-829-76	84CW195 88CW245	Sawyer Lake Creek	40 (fully decreed absolute)	
	C.A. No. 4613	W-829 80CW267 84CW195	Chapman Gulch	300 (fully decreed absolute)	
South Fork Fryingpan River Subsystem	C.A. No. 4613	W-829 84CW195	South Fork Fryingpan River	250 (fully decreed absolute)	
Fryingpan River Subsystem	C.A. No. 4613	W-829 84CW195 88CW245 01CW265 09CW40	Fryingpan River and Marten Creek	400 (395 previously decreed absolute)	5

Table 2 – SECWCD Division 5 North Side Collection System Water Rights

Water Right	Original Decree	Diligence/ Absolute Decrees	Name of Tributary	Total Decreed Amount (cfs)	Conditional (cfs)
North Fork Subsystem	C.A. No. 4613	W-829 84CW195 01CW265 09CW40	Lime Creek*	50	50
			Unnamed Tributary to Slim's Gulch*	85	85
			Slim's Gulch*	85	85
			Last Chance*	135	135
			South Side Intercept of Last Chance*	10	10
			North Side Intercept of N. Fork Fryingpan*	10	10
			Carter Creek	100 (87 previously decreed absolute)	13
			North Fork (Savage Lake Creek)	30 (fully decreed absolute)	
Mormon Creek Subsystem	C.A. No. 4613	84CW195 88CW245 09CW40	Mormon Creek	60 (fully decreed absolute)	
			South Side Intercept of N. Fork Fryingpan*	15	15
Cunningham Creek Subsystem	C.A. No. 4613	80CW267 88CW245 09CW40	North Cunningham Creek	30 (fully decreed absolute)	
			North Cunningham Creek Intercept*	15	15
			Middle Cunningham Creek and S. Cunningham Creek	50 (fully decreed absolute)	
			Unnamed Tributary to S. Cunningham Creek*	30	30
			South Cunningham Creek	20 (fully decreed absolute)	
Ivanhoe Creek Subsystem	C.A. No. 4613	80CW267 84CW195 88CW245 95CW53 09CW40	Ivanhoe Creek	150 (fully decreed absolute)	
			Ivanhoe Creek Intercept*	30	30
			Granite Creek	50 (fully decreed absolute)	
			Fryingpan Intercept Canal*	10	10
	W-829-76	88CW245	Lily Pad Creek	35 (fully decreed absolute)	

*Asterisks indicate diverting structure has not yet been built.

Table 3 – SECWCD Boustead Tunnel Water Rights

Water Right	Original Decree	Diligence Decrees	Name of Tributary	Total Decreed Amount (cfs)
Fryingpan-Arkansas Divide Tunnel (a/k/a Boustead Tunnel)	C.A. No. 4613	W-829 80CW267	All tunnels from North Side and South Side Collection Systems	900 (fully decreed absolute)
	83CW352	96CW087 02CW324	Same sources – enlargement right	100[1] (fully decreed absolute – 1983 priority)

[1]The combined water rights for Boustead Reservoir have been made absolute for 1000 cfs. However, a stipulation among Southeastern, the Colorado River Water Conservation District, the City of Aspen, the Town of Basalt, the Basalt Water Conservancy District, and the U.S. Bureau of Reclamation entered in Case No. 02CW324 limits diversions through the Boustead Tunnel to 945 cfs, except in specific circumstances, and to 900 cfs unless Ruedi Reservoir will fill.

4.0 CONDITIONAL RIGHTS MADE ABSOLUTE

Both the No Name Creek and Unnamed Tributary and the Fryingpan River and Marten Creek locations were able to divert a portion of their remaining conditional water rights since the last diligence filing. According to the records reported in the 2010 AOP, 86 cfs was diverted under the No Name Creek water rights and 406 cfs was diverted under the Fryingpan River and Marten Creek water right on June 6, 2010. **Appendix A** provides the stage and associated discharge tables that were the basis for the 2010 AOP reported diversions. Based on these record diversions, 86 cfs of the No Name Creek and Unnamed Tributary water right (an additional 1 cfs) should be made absolute; and the full 400 cfs of the Fryingpan River and Marten Creek water right (an additional 5 cfs) should be made absolute.

5.0 PROJECT YIELD ANALYSIS

WWG developed a daily Spreadsheet Model to determine the physically and legally available water at the Project decreed points of diversion for the rights previously made absolute and the remaining conditional water rights. The daily Spreadsheet Model process is as follows:

1) Physically available water is estimated from the daily native flow in the river at the originally decreed points of diversion. Estimates of physical flow at each originally decreed diversion point are described in detail below.
2) Physically available water at each point of diversion is limited by legal limitations including bypass flow requirements and Project Water rights.
3) Legally available water under existing Project diversions is further constrained by Project conveyance tunnel capacities.
4) Total Project diversions upstream of the Fryingpan River at Thomasville Gage are further restricted by Fryingpan River flow requirements.

5) Finally, total diversions through Boustead Tunnel are restricted to 945 cfs if Ruedi Reservoir is projected to fill; or 900 cfs from the tributaries to the Fryingpan River if Ruedi Reservoir is not projected to fill.

5.1 Study Period and Model Time Step

The WWG Spreadsheet Model operates on a daily time-step for the period October 1, 1984 through September 30, 2017. October 1, 1984 was selected as the start of the analysis period because the existing facilities were constructed and operational, and available data to inform the spreadsheet model is believed to be reliable. The study period is reasonable as it includes the climate variability seen in the historical record, representing a range of wet, dry, and average year hydrology. For example, the period includes the wet years of 1993, 1995, and 2011; plus the dry years of 2002 and 2012.

5.2 Physical Flow Estimates

The WWG Spreadsheet model uses estimates of natural daily streamflow to determine physical and legal availability for diversions under Project Water rights. In general, natural flows are estimated at long-term USGS streamflow gages or DWR streamflow gages then distributed to upstream tributaries. This standard approach is reasonable for estimating physical flow at the locations of Project Water rights. As shown in **Table 4**, there are periods of missing gaged streamflows, primarily in the winter months. Project diversions do not occur during the winter months; therefore missing winter data does not affect the analyses. However, to allow the Spreadsheet Model to include a complete set of natural flows, standard techniques were used to fill the streamflow data. **Table 4** shows the long-term streamflow gages used to estimate natural flow and the method used to fill missing streamflow. The locations of the streamflow gages compared to major tributaries and Project diversion locations are shown in **Figure 1** above.

Table 4 – Streamflow Gages Used to Estimate Natural Flow

Gage ID	Gage Name	Missing Records	Filling Technique
09074000	Hunter Creek near Aspen	2017 Winter months 2015-2016	2017 filled using regression with Hunter Creek at Aspen (0974500). Winter months filled using "fill-forward" approach.[1)]
09078600	Fryingpan River near Thomasville	No missing data	
09078500	North Fork Fryingpan River near Norrie	No missing data	
09080100	Fryingpan River at Meredith	No missing data	
09079450	Lime Creek near Thomasville	1985-2008 Winter months	Left Missing, gage used to estimate natural flow distribution factors
09078141	North Cunningham Creek Conduit Bypass near Norrie	1985-2008 Winter months	Left Missing, gage used to estimate natural flow distribution factors
09077610	Ivanhoe Creek near Nast	Winter months 2016	Filled using "fill-forward" approach
09078141	North Cunningham Creek Conduit Bypass	1985-2009 Winter months	No filling required, records during Project diversions

1) The Hunter Creek at Aspen Gage (09074500) was not used directly in the analysis due to both a limited period of record (WY 2010 – current), and additional depletions upstream of the gage.

There are measurement devices at the Project diversions that are continuously recorded and believed to be accurate for use in Project accounting. Daily diversions are reported by Reclamation in the AOP and were obtained digitally for the calculation of natural flows. The structures include weirs and flumes that are set so that diversions into the tunnels occur only when bypass flows are met or exceeded. Photos showing examples of the Project diversions and bypass structures taken during a site visit on June 23, 2017 are shown in **Figure 3.**

Figure 3 – Project Diversion Examples (clockwise from left Mormon Creek Diversion, North Cunningham Creek Diversion, South Fork Fryingpan River Diversion)

Streamflow measurements above or below the Project diversions are required to directly calculate historical flow at the Project diversion points. However, with the exception of the North Cunningham Creek Conduit Bypass location, there are no streamflow measurements on the tributaries upstream of the Project diversion points, and active streamflow gages that exist below the Project diversions are much lower in the watershed and include several additional tributaries. Therefore, the natural flow above the Project diversions must be estimated using standard techniques, as described below. The North Cunningham Creek Conduit Bypass gage allows streamflow above the North Cunningham Creek diversion to be calculated directly for recorded period.

The following procedure was used to estimate natural flow above the existing Project diversions and conditional Project Water right decreed points of diversion where facilities have not been constructed.

1. Estimate natural flow at gaged locations as follows. Note that depletions above the gaged locations that are not associated with Project diversions or the Busk-Ivanhoe project are minimal compared to gage flows; therefore these depletions are not removed from gage flows to estimate natural flow conditions.

- Natural Flow at North Fork Fryingpan River near Norrie Gage = Gaged flows + Carter Creek diversions + North Fork (Savage Lake) diversions + Mormon Creek diversions + North Cunningham Creek diversions + Middle Cunningham Creek diversions + South Cunningham Creek diversions
- Natural Flow at Fryingpan River near Thomasville Gage = Gaged flow + Boustead Tunnel diversions (includes all Project diversions above gage plus Hunter Tunnel diversions) + Ivanhoe Reservoir Tunnel diversions – Hunter Tunnel diversions (includes No Name Creek, Midway Creek, and Hunter Creek Project diversions). Note that diversions through Ivanhoe Reservoir Tunnel are recorded by the Division of Water Resources under the Water District identifier (WDID) 3804613.
- Natural Flow at Fryingpan River at Norrie Gage = Estimated Native flow at Fryingpan River near Thomasville Gage – Estimated Native Flow at North Fork Fryingpan River near Norrie Gage
- Natural Flow at Hunter Creek near Aspen Gage = Gaged flows + Hunter Tunnel diversions (includes No Name Creek, Midway Creek, and Hunter Creek Project diversions)
- Natural Flow at the Lime Creek near Thomasville gage was estimated to be 80 percent of the difference between estimated natural flow at the Fryingpan River at Meredith gage and the Fryingpan River at Thomasville gage. The 80 percent factor was based on the measured flow at the short-term Lime Creek near Thomasville gage to allow for a longer period of record.
- Natural Flow at the Ivanhoe Creek near Nast location was estimated by adding in depletions associated with the Busk-Ivanhoe diversions recorded under WDID 3804613 to the Ivanhoe Creek near Nast gage.

2. Distribute portions of natural flow to tributaries based on drainage areas adjusted as appropriate for differences in annual precipitation and aspects (for example, primarily north facing tributaries produce more runoff versus south facing tributaries).
    - The USGS StreamStat programs was used to calculate drainage areas and mean annual precipitation at streamflow gages and for tributaries above each of the Project decreed points of diversion.
    - Initial distribution factors were calculated based as follows:

      (area x precipitation at each diversion location)/
      (area x precipitation at the downstream natural flow gage location)
    - The USGS StreamStat estimates of mean annual flows were used to inform proration factors for distribution of natural flows at gaged locations, along with historical project diversions and bypass requirements. In addition, calculated natural flows at the North Cunningham Creek diversion location were used to fine-tune and validate proration factors for other tributaries.
    - Final proration factors used to distribute natural flows are provided in **Table 5.**

Table 5 – Factors to Distribute Estimated Natural Flow from Gage Locations

Name of Tributary Water Right (Highlight indicates South Side or North Side)	Downstream Natural Flow Gage	Distribution Factor
No Name Creek and Unnamed Tributary	Hunter Creek near Aspen	0.15
Midway Creek	Hunter Creek near Aspen	0.27
Hunter Creek	Hunter Creek near Aspen	0.35
Sawyer Lake Creek	Fryingpan River at Norrie	0.08
Chapman Gulch	Fryingpan River at Norrie	0.15
South Fork Fryingpan River	Fryingpan River at Norrie	0.15
Fryingpan River and Marten Creek	Fryingpan River at Norrie	0.25
Lime Creek*	Lime Creek near Thomasville	1.00
Unnamed Tributary to Slim's Gulch*	Lime Creek near Thomasville	0.02
Slim's Gulch*	Lime Creek near Thomasville	0.02
Last Chance*	North Fork Fryingpan Near Norrie	0.12
South Side Intercept of Last Chance*	North Fork Fryingpan Near Norrie	0.06
North Side Intercept of N. Fork Fryingpan*	North Fork Fryingpan Near Norrie	0.01
Carter Creek	North Fork Fryingpan Near Norrie	0.16
South Side Intercept of N. Fork Fryingpan*	North Fork Fryingpan Near Norrie	0.01
North Fork Savage Lake Creek	North Fork Fryingpan Near Norrie	0.05
Mormon Creek	North Fork Fryingpan Near Norrie	0.19
North Cunningham Creek Intercept*	North Fork Fryingpan Near Norrie	0.03
North Cunningham Creek	North Fork Fryingpan Near Norrie	0.09
Middle Cunningham Creek	North Fork Fryingpan Near Norrie	0.09
South Cunningham Creek	North Fork Fryingpan Near Norrie	0.03
Unnamed Tributary to S. Cunningham Creek*	North Fork Fryingpan Near Norrie	0.01
Ivanhoe Creek Intercept*	Fryingpan River at Norrie	0.01
Ivanhoe Creek	Fryingpan River at Norrie	0.11
Granite Creek	Fryingpan River at Norrie	0.04
Fryingpan Intercept Canal*	Fryingpan River at Norrie	0.01
Lily Pad Creek	Fryingpan River at Norrie	0.04

*Asterisks indicate diverting structure has not yet been built.

5.3 Project Water Rights and Bypass Requirements

Tables 1 through 3 show the absolute and conditional Project Water rights that make up the Fryingpan-Arkansas Project portfolio in the upper Roaring Fork basin. **Figure 1** also shows the decreed diversion points and associated water rights. Most of the Project water rights have a bypass flow requirement that must be met before water can be legally diverted. The WWG Spreadsheet Model limits the physically available flow at each point of diversion by the water rights legal constraints and the bypass flow requirements.

Figure 4 provides a schematic that shows the relative location of the diversions, the associated water rights, and the bypass requirements. Although the bypass requirements are generally seasonal, the project has not historically diverted during the October through March winter season. The April through September bypass requirements are shown in the figure. **Table 6** provides the total water right at each location (sum of absolute and conditional) used as input to the model analysis and the bypass requirements in tabular format. **Table 6** also includes the Water District identifier (WDID) assigned by the Division of Water Resources for each decreed point of diversion. Note that the water rights for diversion structures that have not been constructed do not have set bypass requirements.

In addition, the WWG Spreadsheet Model further limits diversions under water rights on tributaries to the Fryingpan River if minimum flow requirements are not met at the Fryingpan River at Thomasville gage. **Table 7** shows the monthly Thomasville gage flow requirements.

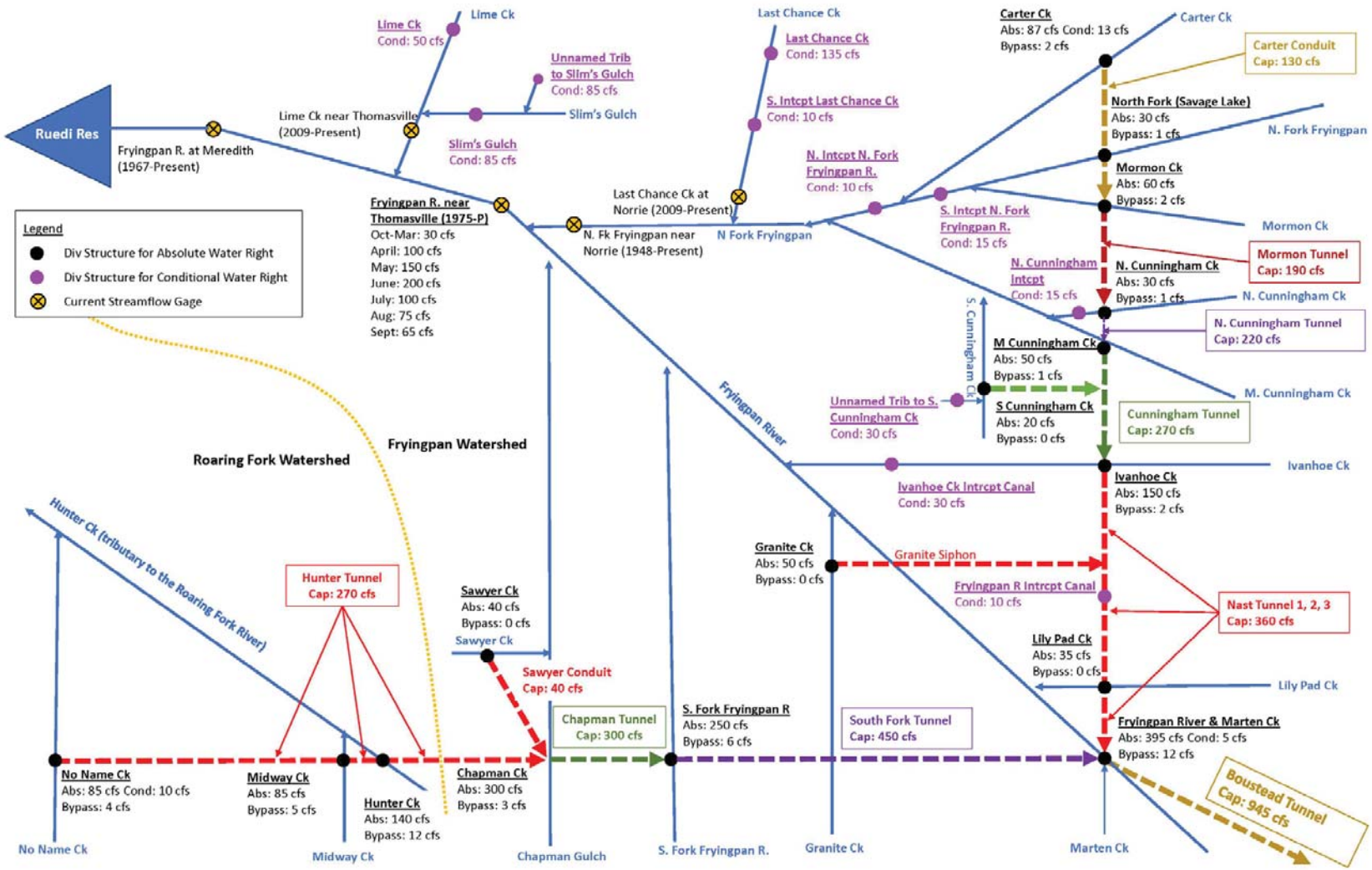

Figure 4 – Project Schematic including Water Rights and Bypass Requirements

Table 6 – Diversion Total Water Right and Bypass Requirements

WDID	Name of Tributary Water Right (Highlight indicates South Side or North Side)	Project Water Right (cfs)	Required Bypass Apr-Sep (cfs)	Required Bypass Oct-Mar (cfs)
3804625	No Name Creek and Unnamed Tributary	95	4	4
3801601	Midway Creek	85	5	5
3801593	Hunter Creek	140	12	12
3801613	Sawyer Lake Creek	40	0	0
3801588	Chapman Gulch	300	3	1.5
3801610	South Fork Fryingpan River	250	6	3
3801590	Fryingpan River and Marten Creek	400	12	6
3801599	Lime Creek*	50[1)]	N/A	N/A
3801614	Unnamed Tributary to Slim's Gulch*	85[1)]	N/A	N/A
3801615	Slim's Gulch*	85[1)]	N/A	N/A
3801597	Last Chance*	135	N/A	N/A
3801612	South Side Intercept of Last Chance*	10	N/A	N/A
3801604	North Side Intercept of N. Fork Fryingpan*	10	N/A	N/A
3801585	Carter Creek	100	2	1
3801585	South Side Intercept of N. Fork Fryingpan*	15	N/A	N/A
3801609	North Fork Savage Lake Creek	30	1	0.5
3801602	Mormon Creek	60	2	1
3901607	North Cunningham Creek Intercept*	15	N/A	N/A
3801606	North Cunningham Creek	30	1	0.5
3801600	Middle Cunningham Creek	50	1	0.5
3801616	South Cunningham Creek	20	0	0
3801617	Unnamed Tributary to S. Cunningham Creek*	30	N/A	N/A
3801596	Ivanhoe Creek Intercept*	30	N/A	N/A
3801595	Ivanhoe Creek	150	2	1
3801592	Granite Creek	50	0	0
3801591	Fryingpan Intercept Canal*	10	N/A	N/A
3801598	Lily Pad Creek	35	0	0
3804625	Boustead Tunnel	1000	n/a	n/a

*Asterisks indicate diverting structure has not yet been built and there are not established bypass requirements.

1) Diversions limited to May and June.

Table 7 – Monthly Flow Requirements at Fryingpan River at Thomasville Gage

Month	Flow Requirement (cfs)
January	30
February	30
March	30
April	100
May	150
June	200
July	100
August	75
September	65
October	30
November	30
December	30

Although the Thomasville gage flow requirements are year-round, the elevation of the Project facilities limits their ability to divert during the winter. Depending on snowpack conditions, Reclamation can generally remove snow on the access roads and prepare for Project diversions in late April or early May. Historically, the Project has stopped diverting by the end of August because there has not been physical water available above the diversion bypass requirements, and Reclamation begins routine maintenance and Project shutdown at the beginning of September. To mimic standard Project operations, the WWG Spreadsheet Model only allows Project diversions from April through August.

5.4 Capacity Constraints of Constructed Tunnels

There are several locations within the feeder tunnel system where available physical and legal diversions could be constrained by physical tunnel capacity limitations during high-flow periods. Similar to actual Reclamation operations, the WWG Spreadsheet Model represents and tracks the physical limitations of tunnel capacities. **Figure 1** above shows the physical location of the individual tunnels that convey water from the diversion location to Boustead Tunnel. **Figure 4** above shows the relative location of the individual tunnels that convey water from the diversion locations to Boustead Tunnel and their associated as-built capacity limitations. **Table 8** provides the tunnel capacity information in a tabular form.

Table 8 – Capacity Constraints of Existing Tunnels

Tunnel Name (Highlight indicates South Side or North Side)	Section Reach	Capacity (cfs)
Hunter Tunnel	No Name Creek to Chapman Creek	270
Sawyer Conduit	Sawyer Creek to Chapman Creek	40
Chapman Tunnel	Chapman Creek to S. Fork Fryingpan River	300
South Fork Tunnel	S. Fork Fryingpan River to Boustead Tunnel	450
Carter Tunnel	Carter Creek to North Fork (Savage Lake Creek)	100
Carter Conduit	North Fork (Savage Lake Creek) to Mormon Creek	130
Mormon Tunnel	Mormon Creek to North Cunningham Creek	190
North Cunningham Tunnel	N. Cunningham Creek to Middle Cunningham Creek	220
Middle Cunningham Tunnel	Cunningham Creek to Ivanhoe Creek	270
South Cunningham Tunnel	South Cunningham Creek to Cunningham Tunnel	20
Nast Tunnel 1, 2, 3	Ivanhoe Creek to Boustead Tunnel	360
Granite Siphon	Granite Creek to Nast Tunnel 1	50
Boustead Tunnel	Fryingpan River to Lake Fork (Upper Arkansas Basin)	945

5.5 Senior Call Consideration

Ruedi Reservoir is used to meet downstream senior calls in exchange for continued diversions under the Project; and as compensatory storage to meet additional west slope demands. Therefore, downstream calls are not included in the model as an additional constraint on Project diversions. Instead, historical information was used to conservatively represent the decree term entered in Case Nos. 02CW324, limiting diversions through the Boustead Tunnel to 900 cfs from tributaries to the Fryingpan River unless Ruedi Reservoir is projected to fill in the WWG Spreadsheet Model based on historical operations.

5.6 Twin Lakes Exchange

The Twin Lakes Exchange is an obligation under the Project authorization. However, water diverted under the exchange is not available for Project allocation and does not count towards project annual or average annual volumetric limitations. The Twin Lakes Exchange is operated based on legal limitations and agreements between cooperating entities that are not specifically included in the WWG Spreadsheet Model. Therefore, the historical amount diverted through the Boustead Tunnel from Midway and No Name Creeks (up to 3,000 acre-

feet/year) is accounted for as Twin Lakes Exchange and decreases the total amount of Project diversions calculated in the model as the final step when determining Project yield.

5.7 Model Calculations

The following describes the Spreadsheet Model daily operations at each of the Project decreed points of diversion. A detailed explanation of the Spreadsheet Model logic is included in a *Readme* worksheet within the WWG Spreadsheet Model. Several discussions were held with Reclamation Project operators to determine if there was a preferred order of operations during high runoff periods when available water exceeds conveyance tunnels or Boustead Tunnel capacities. No clear order of diversions was indicated; therefore the model attempts to divert through the Hunter Creek and South Side collection system independent from the North Side collection system through the tunnels with the least capacity (furthest from Boustead Tunnel) to the tunnels with the most capacity (closest to Boustead Tunnel). These model operations are the least restrictive in terms of capacity limitation.

There have been significant changes in project operations and associated diversions during the study period used for this analysis. Upgraded instrumentation and increased automation have allowed more accurate setting of bypass flows and measurement of diversions. Snow-removal equipment has been purchased to enable Reclamation to open the system facilities earlier and capture more of the runoff period.

The first section of the WWG Spreadsheet Model operates the as-built system water rights and associated diversions under “optimal” conditions to remove operational limitations while meeting physical and legal diversion limitations. Optimal conditions include the ability to fully automate radial gates, allowing adjustments to quickly occur with changes in streamflow. The second section of the WWG Spreadsheet Model estimates the physical and legal diversions available under the conditional water rights at locations where Project facilities do not exist.

The following sections follow model “steps” as they are grouped in the model and discussed in the model documentation.

5.7.1 Potential Yield of Existing Project Facilities

Initial Flow Data

Step 1 includes the natural flow estimates at streamgage locations used to determine physical flow at the decreed Project points of diversion, as discussed in Section 4.2.

Hunter Creek Collection System

Step 2 determines the physical and legal water available at the Project decreed points of diversion to Hunter Tunnel as the minimum of physical natural flow less bypass requirements, using the initial flow data from Step 1, and the water rights at each of the three decreed diversion locations. The water rights for the three Project diversions in the Hunter Creek

collection system (No Name, Midway, and Hunter Creek) add up to more than Hunter Tunnel capacity. Total diversions through Hunter Tunnel are limited to 270 cfs.

South Side Collection System

Step 3 determines the physical and legal water available at the Project decree points of diversion to Chapman Tunnel and South Fork Tunnel as the minimum of the water rights and physical natural flow less bypass requirements at each of the three points of diversion (Sawyer Creek, Chapman Creek, and South Fork Fryingpan River). Similar to the Hunter Creek collection system, there are times when Hunter Creek diversions plus legally available water at the South Side points of diversion exceed the Chapman Tunnel and/or the South Fork Tunnel capacity. Total diversions are limited to the individual tunnel capacities.

North Side Collection System

Step 4 determines the physical and legal water available at the Project decree points of diversion to Carter Conduit, Mormon Tunnel, Cunningham Tunnel, and the Nast Tunnels as the minimum of the water rights and physical natural flow less bypass requirements at each of the nine points of diversion, as shown in **Figure 4**. Similar to the South Side collection system, there are times when the legally available water at the North Side points of diversion exceeds the conveying tunnel capacity. This specifically can occur at the South Cunningham Tunnel and each of the three segments of the Nast Tunnel. Total diversions are limited to the individual tunnel capacities.

Boustead Diversions

Step 5 sums the remaining flows after Steps 2 and 3 diversions that are tributary to the Fryingpan River near Thomasville gage and compares the flows to the Thomasville minimum flow requirements. If the minimum flow requirements are not met, then water diverted from the Fryingpan River tributaries is “spilled” back to the river. The remaining diversions through the North and South Side collection systems, including Hunter Creek diversions, plus legally and physically available water at the Fryingpan River and Marten Creek diversion location are accumulated as available diversions to Boustead Tunnel. Depending on whether Ruedi Reservoir had been projected to fill in the analysis year, Boustead Tunnel diversions are the minimum of accumulated available diversions and either 945 cfs total, or 900 cfs from tributaries to the Fryingpan River plus up to an additional 45 cfs from the Hunter Creek tributary diversions, when up to an additional 45 cfs from the Hunter Creek tributary diversions can be released to the Fryingpan River.

There were three years during the study period that Reclamation noted in the AOP that diversions through Boustead Tunnel were restricted due to high levels of east-slope Project storage (1987, 1988, and 1996). Reclamation and SECWCD have some discretion on Project storage operations in the Arkansas River basin, and other Arkansas River basin user demands

and operations have changed since 1996. Therefore, the model does not consider Arkansas River basin storage constraints when determining Division 5 water right yields.

5.7.2 Potential Yield of Conditional Water Rights without Existing Facilities

Potential diversions under conditional water rights where Project facilities have not been constructed are calculated as the minimum of estimated physical flow at each decreed location, conditional water rights, and bypass requirements – similar to the calculation at as-built locations. However, no conveyance tunnel capacity restrictions are included; only the restrictions on total diversions through Boustead Tunnel.

6.0 PROJECTED YIELD RESULTS

The following sections provide the results of the project yield analysis using the WWG Spreadsheet Model.

6.1 Projected Yield of Existing Project Facilities

The projected yield is based on optimal operation of existing Project facilities. As highlighted above, as Reclamation has improved operations and accessed facilities earlier in the runoff, historical diversions have increased significantly. Even though the Colorado River basin has been in drought conditions since the early 2000s, the average annual Project diversions through Boustead Tunnel for the period 2002 through 2017 have increased by 17 percent over the diversions from 1985 through 2001 – indicating that more efficient Project operations have increased Project yield by a significant amount. Even when the three years in which diversions were limited due to east slope storage are excluded (1987, 1988, 1996), 2002 through 2017 average annual diversions increased by 3 percent over the period 1985 through 2001.

Based on the methodology presented, the WWG Spreadsheet model indicates that with optimal operations, the water rights associated with the existing Project facilities could provide the 69,200 acre-feet of average annual yield as projected in the Project authorization and concluded in the Reclamation 1975 Final Environmental Impact Statement. **Figure 5** shows the estimated potential annual Project diversions through the Boustead Tunnel based on the WWG Spreadsheet Model plus historical Project diversions for comparison. The potential average annual yield over the 33-year study period was estimated to be 73,834 acre-feet; with a minimum annual estimated diversion of 15,680 acre-feet in 2012 (a representative drought year) and a maximum annual estimated diversion of 119,331 acre-feet in 1995 (a representative wet year).

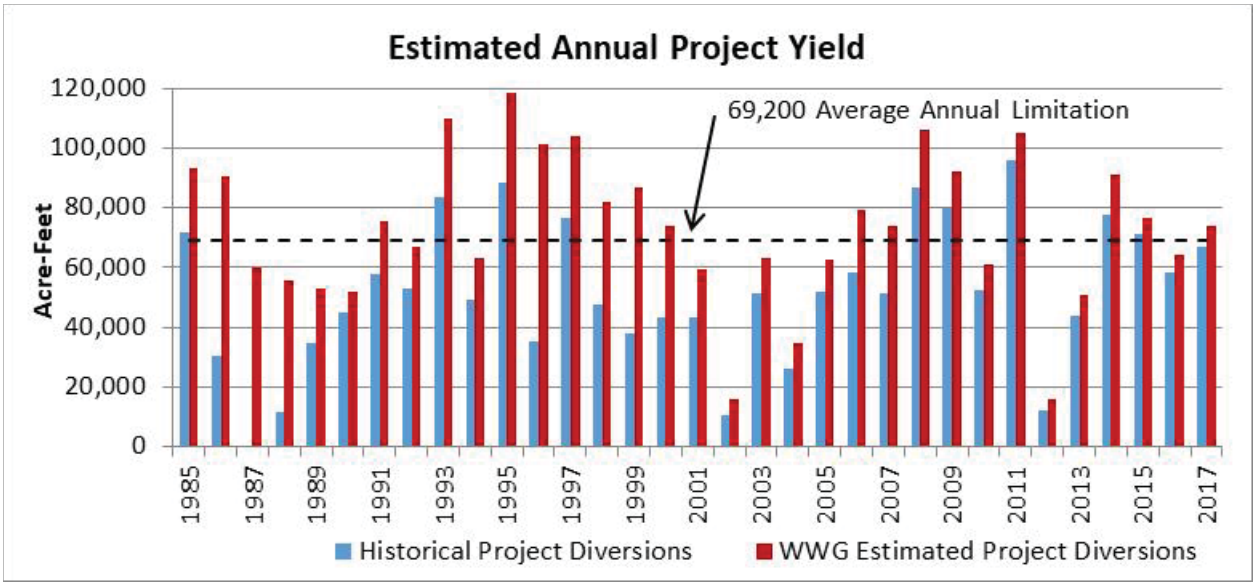

Figure 5 – Estimated Annual Project Yield Comparison

As shown, historical yield in recent years more closely represents optimal conditions than yield in the earlier study period. Estimated Project diversions are higher than historical Project diversions for the South Side collection system, the North Side collection system, and the Fryingpan and Marten Creek Diversions, as shown in **Figures 6 through 8**.

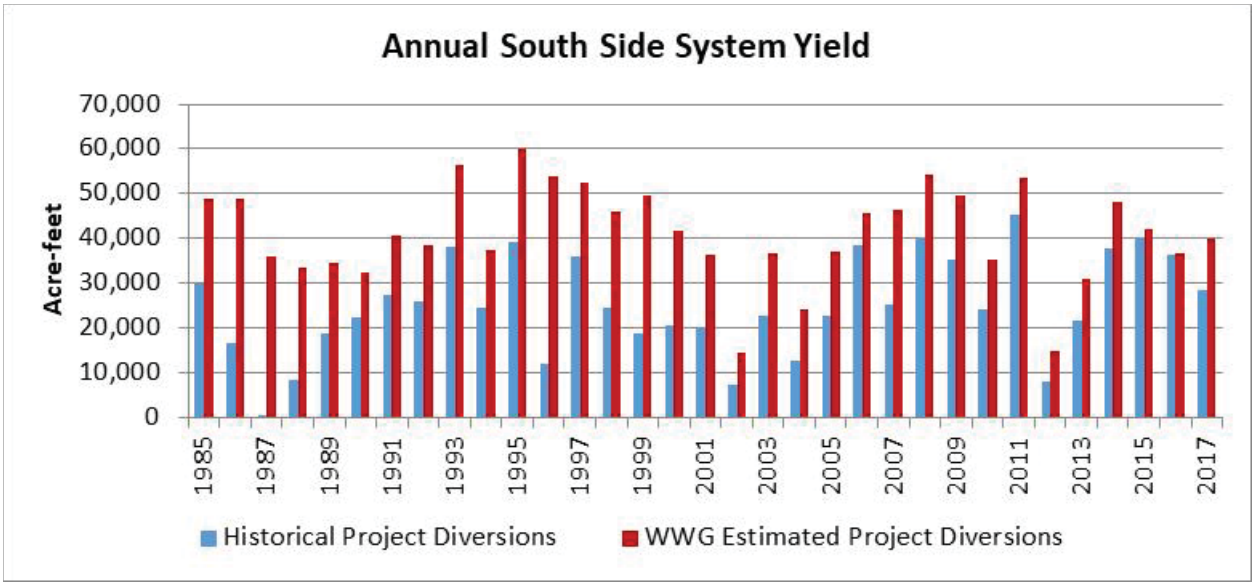

Figure 6 – Estimated Annual South Side System Yield Comparison

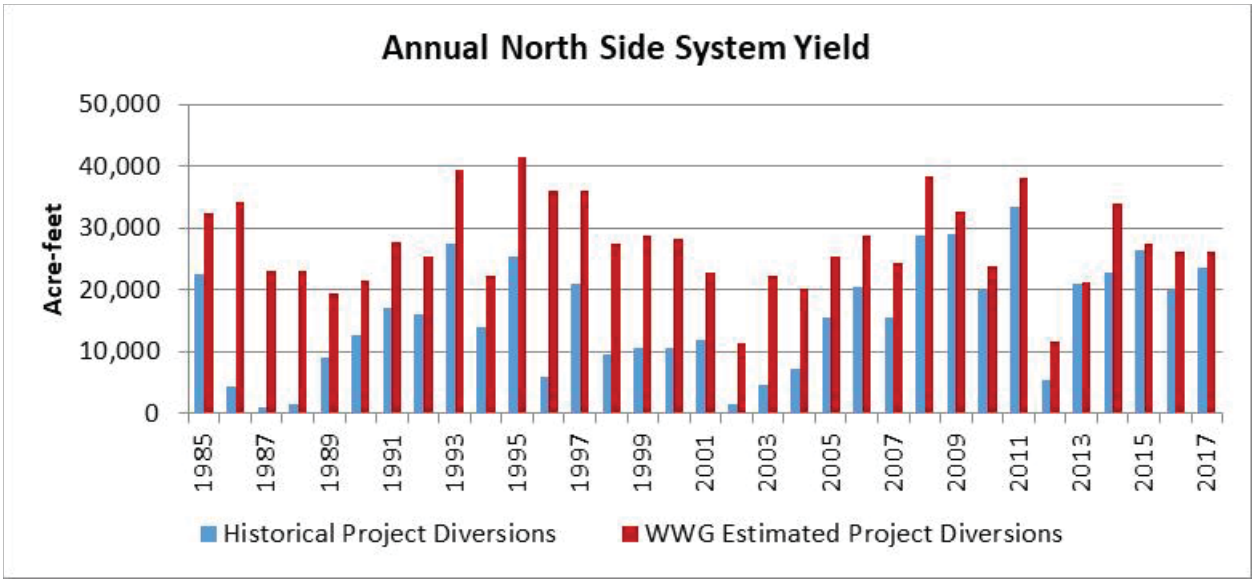

Figure 7 – Estimated Annual North Side System Yield Comparison

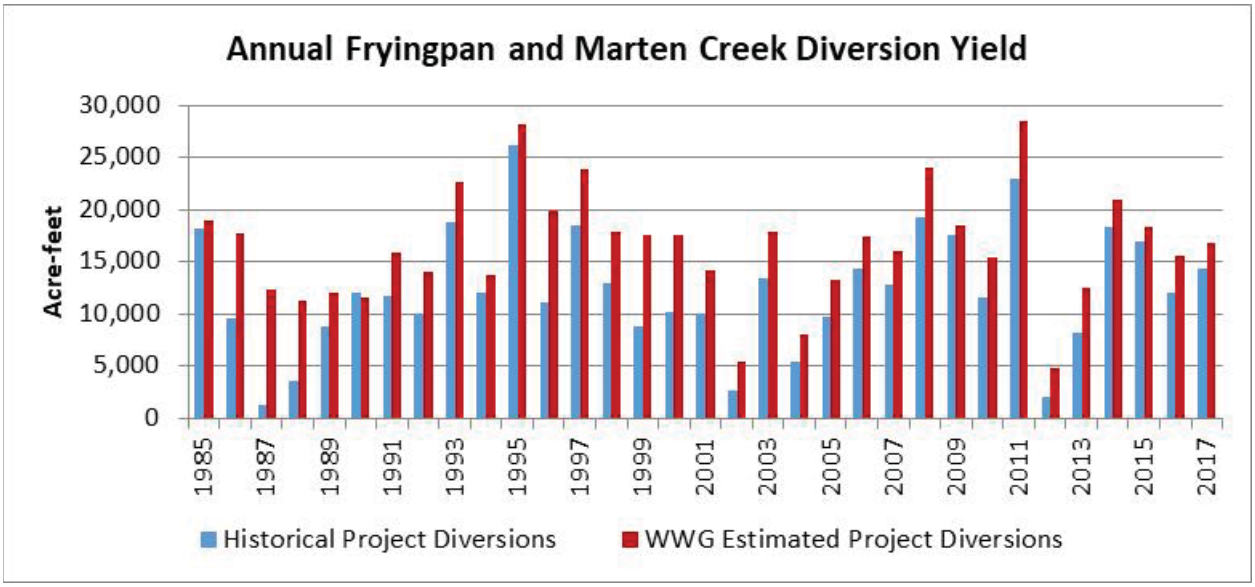

Figure 8 – Estimated Annual Fryingpan and Marten Creek Diversion Yield Comparison

As discussed in **Section 4.2**, there are no flow measurements on most of the tributaries with existing diversion points. Based on the natural flows estimated, water has been available to meet the full remaining conditional water rights at decreed locations with existing facilities (No Name Creek, Carter Creek, and Fryingpan River Marten Creek diversion locations).

6.2 Projected Yield of Conditional Rights without Existing Facilities

As shown in Section 5.1, the WWG Spreadsheet model indicates the authorized average annual Project yield of 69,200 acre-feet could be met from water rights associated with existing facilities under optimum operations. However, the actual average annual yield of the Project has fallen short of the authorized yield and it is unclear whether on the ground operations can

be optimized to the level modeled by WWG. Therefore, the WWG Spreadsheet model investigated additional yield that could be met from conditional water rights that have decreed locations but have not been developed to date.

The WWG Spreadsheet model does not allow diversions of the conditional water rights above the Thomasville gage unless the Thomasville flow requirements, shown in **Table 7** are met. The Operating Principles limit the diversions of conditional rights on Lime Creek to May and June only. The model estimates diversions of the conditional water rights only when the total Project diversions under all rights (absolute and conditional) are estimated to be less than the Boustead Tunnel capacity restrictions considering the Ruedi Reservoir fill projections. Note that the WWG Spreadsheet model diverts the Project absolute rights through Boustead Tunnel first; remaining Boustead Tunnel capacity often limits diversions under the conditional water rights.

The estimated combined average annual yield of the conditional water rights is 6,490 acre-feet. The yield varies from a minimum of 2,740 acre-feet in 2002 to a maximum of 9,820 acre-feet in 1996, as shown in **Figure 9**.

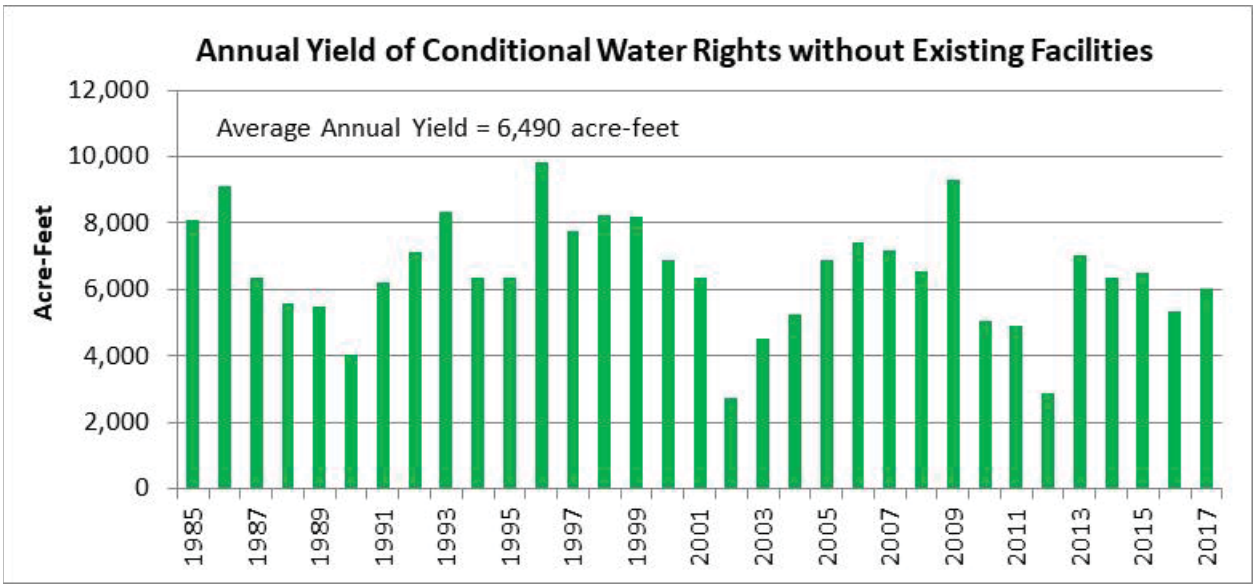

Figure 9 – Projected Yield of Conditional Water Rights without Existing Facilities

As discussed in **Section 4.2** and shown in **Figure 1**, there are no long-term flow measurements on the tributaries with conditional water rights but no existing diversion structures. However, there are some short term gages on lower Lime Creek and lower Last Chance Creek that were used to calibrate natural flow estimates on those tributaries. Based on the estimated natural flows, physically water supplies may be less than the full conditional rights at some of the decreed locations without existing facilities. **Table 9** shows the conditional water rights and the estimated legal water available limited by physical supply. Note that this available water does not consider other restrictions, including Boustead Tunnel capacity.

Table 9 – Water Available for Conditional Water Rights without Existing Facilities

WDID	Name of Tributary Water Right (Conditional Rights all on North Side)	Conditional Water Right (cfs)	Water Available to Water Right (cfs)
3801599	Lime Creek*	50	50
3801614	Unnamed Tributary to Slim's Gulch*	85	11
3801615	Slim's Gulch*	85	14
3801597	Last Chance*	135	77
3801612	South Side Intercept of Last Chance*	10	10
3801604	North Side Intercept of N. Fork Fryingpan*	10	7
3801585	South Side Intercept of N. Fork Fryingpan	15	5
3901607	North Cunningham Creek Intercept	15	15
3801617	Unnamed Tributary to S. Cunningham Creek	30	4
3801596	Ivanhoe Creek Intercept	30	16
3801591	Fryingpan Intercept Canal	10	9

* Asterisks indicate decreed location within the Holy Cross Wilderness.

7.0 OPPORTUNITIES FOR DEVELOPMENT OF CONDITIONAL WATER RIGHTS

As indicated in **Table 9**, six of the conditional water rights without existing diversion structures are located within the Holy Cross Wilderness. The remaining five conditional water rights without existing diversion structures are located outside the wilderness area. Several opportunities to develop the conditional water rights both within and outside the wilderness area were considered. The following were considered to be the most feasible:

1. Construct feeder tunnels from the conditional water rights located outside the Holy Cross Wilderness to existing tunnels
2. Change the conditional water rights located within the Holy Cross Wilderness to diversion outside the wilderness area and construct pump stations and pipelines to delivery to Boustead Tunnel
3. Change the conditional water rights located within the Holy Cross Wilderness to storage outside the wilderness area and to release to meet Thomasville gage flow requirements

7.1 Deliver Conditional Water Rights from Outside the Holy Cross Wilderness to Boustead Tunnel

Five of the conditional water rights are in close proximity to existing conveyance tunnels, as shown in the **Figure 3** schematic, and are outside the Holy Cross Wilderness. Diversion structures and new canals or tunnels could be constructed that would allow these water rights

to gravity-feed into existing tunnels or be pumped for short distances when capacity exists in existing conveyances conduits/tunnels and Boustead Tunnel. These diversions were evaluated considering the 900 or 945 cfs capacity limitations:

- South Side Intercept of N. Fork Fryingpan River diversion could be pumped to Mormon Tunnel
- North Cunningham Creek Intercept could be pumped to North Cunningham Tunnel
- Unnamed Tributary to S. Cunningham Creek could be gravity fed into Cunningham Tunnel
- Ivanhoe Creek Intercept Canal could be pumped to Nast Tunnel 1
- Fryingpan River Intercept Canal could be gravity fed into Nast Tunnel 2

Based on the WWG Spreadsheet model, by constructing diversion structures and tunnels to connect these conditional water rights to existing Project infrastructure the average annual Project yield could be increased by 1,210 acre-feet. As shown in **Figure 10**, the estimated annual yield ranges from 115 acre-feet in 2012 to 2,350 acre-feet in 1993 from these five conditional water rights.

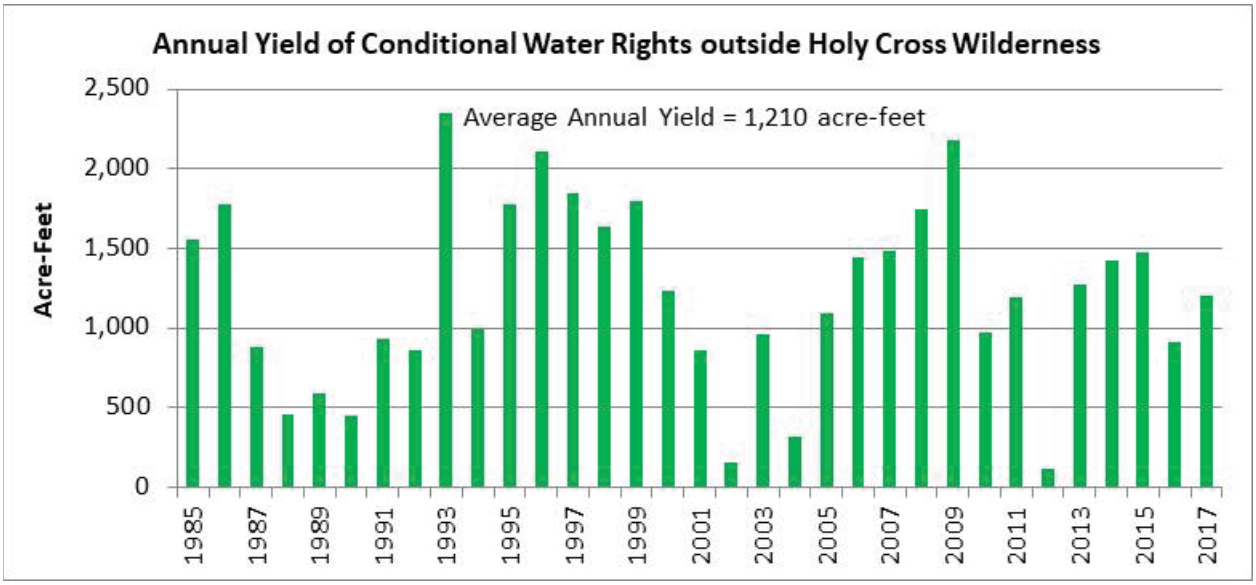

Figure 10 – Annual Yield of Conditional Rights outside Holy Cross Wilderness

7.2 Deliver Conditional Water Rights in the Holy Cross Wilderness to Boustead Tunnel

WWG analyzed changing the remaining six conditional rights to diversion locations outside the Holy Cross Wilderness. Diversion structures, pipelines, and pump stations could be constructed to convey the water to Boustead Tunnel. The amount of water physically and legally available at the original decreed locations would be quantified and diverted at the new points of diversion. The WWG Spreadsheet model estimates that the increased Project yield for this option is 6,260 acre-feet. As shown in **Figure 11,** these conditional rights could provide significant additional Project yield, even in the driest years of 2002 (2,600 acre-feet) and 2012 (2,760 acre-feet).

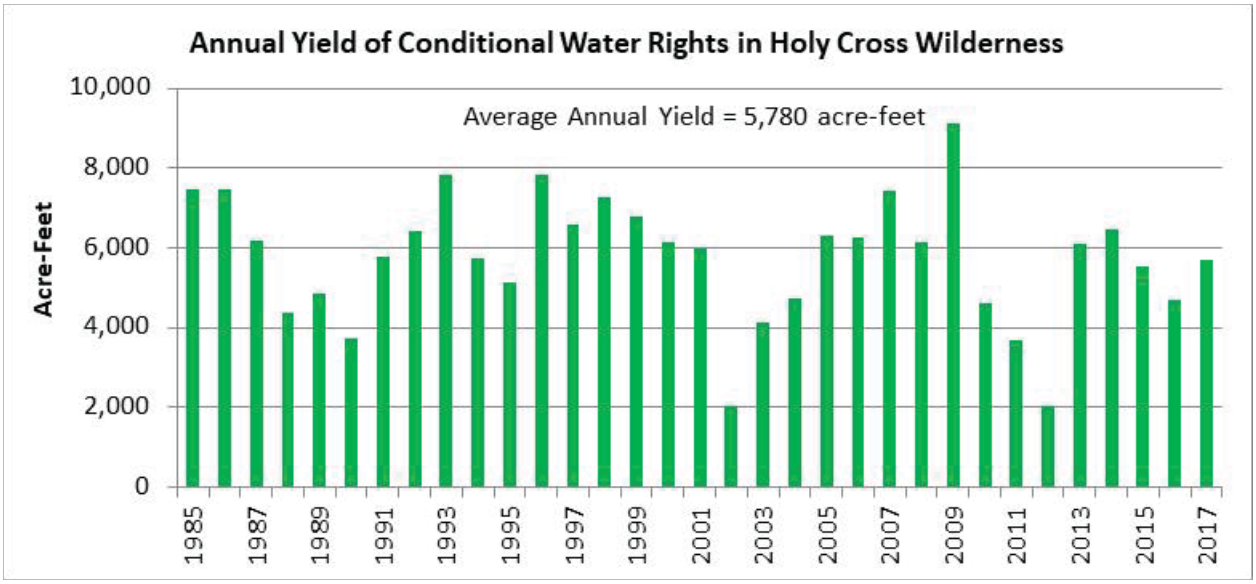

Figure 11 – Annual Yield of Conditional Rights in Holy Cross Wilderness

7.3 Store Conditional Water Rights and Release Water to meet Thomasville Gage Flow Requirements

Another option for developing the eleven conditional water rights is to change all points of diversion to a location outside the wilderness area and construct a reservoir to store the diversions. Then releases from the reservoir could be used to meet Thomasville gage flow requirements. This would allow increased diversions through existing facilities when the Thomasville gage flow requirement is the constraint on diversions.

Several feasible storage sites were investigated on Lime Creek and the Fryingpan River through topographic mapping and subsequent site visits. A reservoir yield analysis estimated that a 4,000 acre-feet reservoir on Lime Creek could increase the project yield by approximately 4,200 acre-feet. A 4,000 acre-feet reservoir on the Fryingpan River could increase the Project yield by approximately 4,800 acre-feet.

8.0 ADDITIONAL DILIGENCE EFFORTS

8.1 Reclamation and U.S Forest Service Meetings, Site Visits, and WWG Spreadsheet Review

As discussed in Section 4.7, the WWG Spreadsheet Model indicated that if the existing facilities were operated more efficiently, the current absolute water rights could provide the full Project yield over the 33-year analysis period. To better understand the difference between model-estimated yield and historical yield, WWG and SECWCD staff visited the existing facility diversion locations on June 23, 2017 with one of the long-term Reclamation Project operators. The goal was to specifically understand preferred order of diversions, especially during high runoff when conveyance tunnel capacity may restrict diversions at certain locations, to enhance

operations of the WWG Spreadsheet model. The Reclamation Project operator was able to provide guidance for some of the system, and confirmed that diversions through existing facilities do not generally follow a set order.

Since the last diligence filing, Reclamation performed an operation and maintenance assessment of the system, resulting in several findings and recommendations. SECWCD was provided with the Replacement, Additions, and Extraordinary Maintenance (RAX) Item Justifications, authorizing replacement and upgrades for some of the recommended improvements. The assessment resulted in the following funded recommendations:

- The collection system radial gate actuators and ancillary equipment need to be replaced at 14 of the 15 diversion sites. Over $1.15M in funding was approved for this effort, and is currently projected to begin in FY 2018 and to be completed in FY 2019. The study noted that actuator failures due to age could impact Project deliveries.
- Boustead Tunnel weep holes (drains) need to be cleaned to assure that hydrostatic pressure does not build to the point of potential tunnel failures. This $1.5M effort, which began in FY 2012 and is scheduled to be completed in FY 2021, is critical for continued Project deliveries.
- Erosion around the Cunningham Tunnel invert has created voids in the flowline of the tunnel and there are localized areas where significant scour damage exists. This $1.835M effort will begin in FY 2018 and may extend through FY 2020.
- Microwave repeater radios, currently used in partnership with the State of Colorado Digital Trunked Radio System, need to be replaced at the Granite and Hagerman communication sites. This $715,000 effort began in FY 2018 and is scheduled to be completed in FY 2018.

The Reclamation Project operator indicated that upgrading the radial gate actuators is a good first step, but more may need to be done to better optimize the system; including updating the existing software that is used to remotely adjust the gates to capture changes in runoff and diurnal flows, and replacing current headgates with lighter aluminum headgates designed to handle more dynamic and frequent setting changes and reduce load on actuators. Currently, the types of headgates vary throughout the system; and standardized headgates would allow for more efficient repairs and replacements.

WWG and SECWCD staff met with Reclamation staff in the Loveland Area office on February 9, 2017 to discuss diligence efforts, the analyses performed using the WWG Spreadsheet Model, and the potential Project improvements to increase yield. On March 29, 2017, WWG staff met with Reclamation operations staff at the Pueblo Reservoir field office to explain the WWG Spreadsheet model in detail and discuss opportunities to improve the analysis. On April 3, 2017, WWG and SECWCD staff also met with representatives from the U.S. Forest Service to discuss the diligence efforts.

9.0 SUMMARY AND OPINION

As documented in this report, we have analyzed the Fryingpan-Arkansas Project conditional water rights in support of diligence, as outlined in the application in Case No. 2018CW3063. The following opinions are based on our analysis and discussions with Reclamation staff.

- It is my opinion that the historical diversions have fallen short of the authorized Project yield.
- It is my opinion that diversion records appropriately show that 86 cfs has been diverted under the No Name Creek and Unnamed Tributary water right since the last diligence filing and that total amount should be made absolute.
- It is my opinion that diversion records appropriately show that 400 cfs has been diverted under the Fryingpan River and Marten Creek water right since the last diligence filing and that total amount should be made absolute.
- It is my opinion that the use of Fryingpan-Arkansas Project Water as a supplemental source to senior direct flow rights and the common shortages to full allocation indicate that there is a need for additional diversions under the Division 5 absolute and conditional water rights.
- It is my opinion that the study period used in the analysis is reasonable; containing wet, dry, and average hydrological periods.
- It is my opinion that under optimal operations, the existing Project infrastructure could yield the average annual 69,200 acre-feet authorized in the original Project Operating Principles and Decrees and confirmed in the 1975 Final Environmental Impact Statement.
- It is my opinion that water is physically and legally available to meet the full decreed water right at the No Name Creek and Unnamed Tributary diversion location and that diligence should continue on the remaining 4 cfs conditional portion of that water right for the next six years.
- It is my opinion that water is physically and legally available to meet the full decreed water right at the Carter Creek diversion location and that diligence should continue on the remaining 13 cfs conditional portion of that water right for the next six years.
- It is my opinion that there is physically and legally available water under each of the conditional water rights at locations without existing diversion structures to divert all or a portion of the full decreed conditional water rights, and that diligence should continue for the next six years.
- It is my opinion that there are feasible opportunities to develop the conditional water rights, including new tunnels and pump stations and new reservoir storage.
- It is my opinion that it is reasonable for Reclamation and SECWCD to continue to optimize operations to increase Project yield before building new facilities to develop conditional rights.

- It is my opinion that engineering performed, including development of a Point Flow model; analysis of historical Project yield; review of current Reclamation Project operations; and investigation of opportunities to develop the conditional rights outside the wilderness area, and the associated costs incurred by SECWCD show reasonable diligence on the conditional rights.
- It is my opinion that the engineering performed meets the requirements of the Stipulation with the U.S. Forest Service in the prior diligence Case No. 09CW40.

10.0 LIST OF DOCUMENTS AND INFORMATION RELIED ON FOR THIS REPORT

1) Judgment and Decree, Case No. 40487, December 17, 1979, and Exhibit 8 SECWCD Allocation Principles, Findings, Determinations, and Resolutions, November 29, 1979
2) Southeastern Colorado Water Activity Enterprise Water Allocation Policy Fryingpan-Arkansas Project Water, amended April 18, 2013
3) Operating Principles Fryingpan-Arkansas Project, April 30, 1959, House Document 130, as amended December 30, 1959 and December 9, 1960
4) Colorado Division of Water Resources. 2016. CDSS Online Tools and Databases. http://cdss.state.co.us/
5) Finding and Decree, Case No. 4613, Garfield County District Court (July 21, 1959)
6) Finding and Decree, Case No. 5141, Chaffee County District Court(July 9, 1969)
7) Decree, Case No. 80CW6, District Court, Water Division 2 (October 23, 1980)
8) Decree, Case No. 10CW23, District Court, Water Division 2 (October 26, 2010)
9) Correspondence with Roy Vaughan and Theresa Dawson, U.S. Bureau of Reclamation
10) Correspondence with Mike Gallagher, U.S. Bureau of Reclamation
11) Resource and Engineering Planning Committee Meeting, Fry-Ark OM&R and RAX Projected Work Plan Information Report, USBR (September 7, 2017)
12) Annual Operating Plans, Fryingpan-Arkansas Project, Colorado (1984 to 2017)
13) Final Environmental Impact Statement, Fryingpan-Arkansas Project, Reclamation (1975)
14) Decree in Case No. W-829-76 (Division 5)
15) Decree in Case No. 09CW40 (Division 5)
16) Stipulation in Case No. 09CW40 with the United States

APPENDIX A - ABSOLUTE WATER RIGHT CLAIM TABLES

Fryingpan River at Marten Creek Diversion

The Fryingpan River at Marten Creek diversion reached a maximum instantaneous rate of diversion of 406 cfs on June 6, 2010 at 6:30 PM. The diversion has a 12-foot Parshall flume with the non-standard equation, provided by Reclamation, as follows:

$Q = 53.29h^{1.5}$ where Q is the flowrate in cfs and h is the stage in feet

Figure 1A provides the 15-minute data for June 6, 2010.

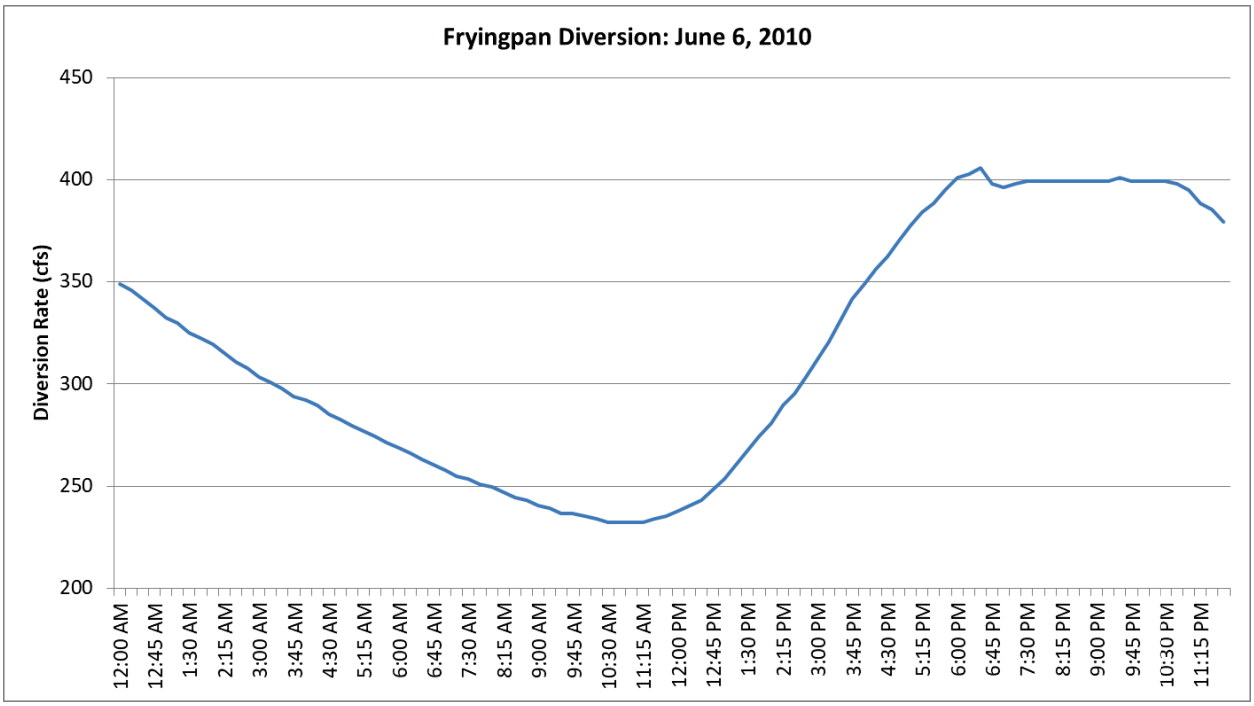

Figure 1A – Instantaneous Diversion Measurements at Fryingpan Diversion for June 6, 2010

Table 1A includes the instantaneous stage and associated discharge measurements provided by Reclamation.

Table 1A – Instantaneous Stage and Discharge Measurements Fryingpan River at Marten Creek Diversion for June 6, 2010.

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 12:00 AM	3.50	348.94
6/6/2010 12:15 AM	3.48	345.95
6/6/2010 12:30 AM	3.45	341.49
6/6/2010 12:45 AM	3.42	337.04
6/6/2010 1:00 AM	3.39	332.62
6/6/2010 1:15 AM	3.37	329.68
6/6/2010 1:30 AM	3.34	325.29
6/6/2010 1:45 AM	3.32	322.37
6/6/2010 2:00 AM	3.30	319.46
6/6/2010 2:15 AM	3.27	315.11
6/6/2010 2:30 AM	3.24	310.79
6/6/2010 2:45 AM	3.22	307.91
6/6/2010 3:00 AM	3.19	303.62
6/6/2010 3:15 AM	3.17	300.77
6/6/2010 3:30 AM	3.15	297.93
6/6/2010 3:45 AM	3.12	293.68
6/6/2010 4:00 AM	3.11	292.27
6/6/2010 4:15 AM	3.09	289.46
6/6/2010 4:30 AM	3.06	285.25
6/6/2010 4:45 AM	3.04	282.46
6/6/2010 5:00 AM	3.02	279.68
6/6/2010 5:15 AM	3.00	276.90
6/6/2010 5:30 AM	2.98	274.14
6/6/2010 5:45 AM	2.96	271.38
6/6/2010 6:00 AM	2.94	268.64
6/6/2010 6:15 AM	2.92	265.90
6/6/2010 6:30 AM	2.90	263.17
6/6/2010 6:45 AM	2.88	260.46
6/6/2010 7:00 AM	2.86	257.75
6/6/2010 7:15 AM	2.84	255.05
6/6/2010 7:30 AM	2.83	253.70
6/6/2010 7:45 AM	2.81	251.02
6/6/2010 8:00 AM	2.80	249.68
6/6/2010 8:15 AM	2.78	247.01
6/6/2010 8:30 AM	2.76	244.35
6/6/2010 8:45 AM	2.75	243.02
6/6/2010 9:00 AM	2.73	240.38
6/6/2010 9:15 AM	2.72	239.06
6/6/2010 9:30 AM	2.70	236.42
6/6/2010 9:45 AM	2.70	236.42

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 10:00 AM	2.69	235.11
6/6/2010 10:15 AM	2.68	233.80
6/6/2010 10:30 AM	2.67	232.49
6/6/2010 10:45 AM	2.67	232.49
6/6/2010 11:00 AM	2.67	232.49
6/6/2010 11:15 AM	2.67	232.49
6/6/2010 11:30 AM	2.68	233.80
6/6/2010 11:45 AM	2.69	235.11
6/6/2010 12:00 PM	2.71	237.74
6/6/2010 12:15 PM	2.73	240.38
6/6/2010 12:30 PM	2.75	243.02
6/6/2010 12:45 PM	2.79	248.34
6/6/2010 1:00 PM	2.83	253.70
6/6/2010 1:15 PM	2.88	260.46
6/6/2010 1:30 PM	2.93	267.27
6/6/2010 1:45 PM	2.98	274.14
6/6/2010 2:00 PM	3.03	281.07
6/6/2010 2:15 PM	3.09	289.46
6/6/2010 2:30 PM	3.13	295.10
6/6/2010 2:45 PM	3.19	303.62
6/6/2010 3:00 PM	3.25	312.23
6/6/2010 3:15 PM	3.31	320.91
6/6/2010 3:30 PM	3.38	331.15
6/6/2010 3:45 PM	3.45	341.49
6/6/2010 4:00 PM	3.50	348.94
6/6/2010 4:15 PM	3.55	356.44
6/6/2010 4:30 PM	3.59	362.48
6/6/2010 4:45 PM	3.64	370.08
6/6/2010 5:00 PM	3.69	377.73
6/6/2010 5:15 PM	3.73	383.89
6/6/2010 5:30 PM	3.76	388.53
6/6/2010 5:45 PM	3.80	394.75
6/6/2010 6:00 PM	3.84	401.00
6/6/2010 6:15 PM	3.85	402.57
6/6/2010 6:30 PM	3.87	405.71
6/6/2010 6:45 PM	3.82	397.87
6/6/2010 7:00 PM	3.81	396.31
6/6/2010 7:15 PM	3.82	397.87
6/6/2010 7:30 PM	3.83	399.43
6/6/2010 7:45 PM	3.83	399.43
6/6/2010 8:00 PM	3.83	399.43
6/6/2010 8:15 PM	3.83	399.43

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 8:30 PM	3.83	399.43
6/6/2010 8:45 PM	3.83	399.43
6/6/2010 9:00 PM	3.83	399.43
6/6/2010 9:15 PM	3.83	399.43
6/6/2010 9:30 PM	3.84	401.00
6/6/2010 9:45 PM	3.83	399.43
6/6/2010 10:00 PM	3.83	399.43
6/6/2010 10:15 PM	3.83	399.43
6/6/2010 10:30 PM	3.83	399.43
6/6/2010 10:45 PM	3.82	397.87
6/6/2010 11:00 PM	3.80	394.75
6/6/2010 11:15 PM	3.76	388.53
6/6/2010 11:30 PM	3.74	385.44
6/6/2010 11:45 PM	3.70	379.27

No Name Creek Diversion

The No Name diversion reached a maximum instantaneous rate of diversion of 86 cfs on June 6, 2010 at 7:15 PM. The No Name Diversion has an 8-foot weir with equation (7-1) from the Water Measurement Manual. After the equation coefficients are input, the equation is as follows:

$Q = (3.22 + 0.2h)(7.997)(h + 0.003)^{1.5}$ where Q is the flowrate in cfs and h is the stage in ft

Figure 2A provides the 15-minute data for June 6, 2010.

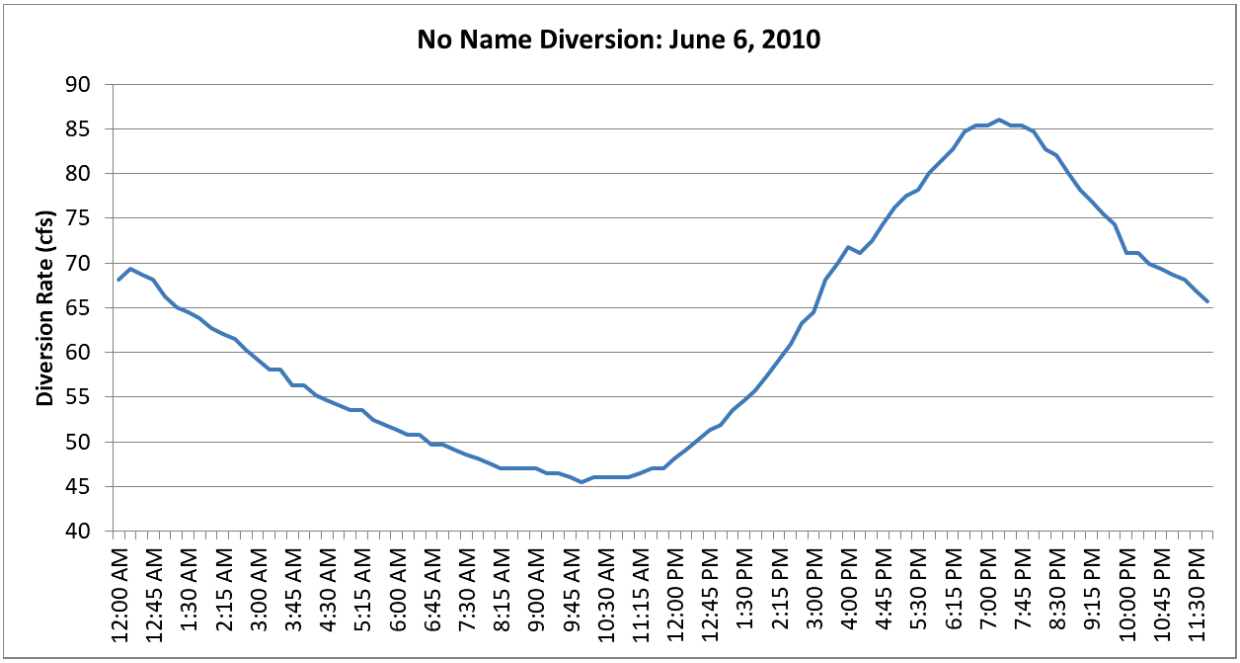

Figure 2A – Instantaneous Diversion Measurements at the No Name Diversion for June 6, 2010

Table 2A includes the instantaneous stage and associated discharge measurements provided by Reclamation.

Table 1A – Instantaneous Stage and Discharge Measurements
Fryingpan River at Marten Creek Diversion for June 6, 2010

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 0:00	1.78	68.09
6/6/2010 0:15	1.80	69.31
6/6/2010 0:30	1.79	68.70
6/6/2010 0:45	1.78	68.09
6/6/2010 1:00	1.75	66.26
6/6/2010 1:15	1.73	65.06
6/6/2010 1:30	1.72	64.46
6/6/2010 1:45	1.71	63.86
6/6/2010 2:00	1.69	62.68
6/6/2010 2:15	1.68	62.09
6/6/2010 2:30	1.67	61.50
6/6/2010 2:45	1.65	60.33
6/6/2010 3:00	1.63	59.18
6/6/2010 3:15	1.61	58.03
6/6/2010 3:30	1.61	58.03
6/6/2010 3:45	1.58	56.32
6/6/2010 4:00	1.58	56.32
6/6/2010 4:15	1.56	55.19

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 4:30	1.55	54.63
6/6/2010 4:45	1.54	54.08
6/6/2010 5:00	1.53	53.52
6/6/2010 5:15	1.53	53.52
6/6/2010 5:30	1.51	52.42
6/6/2010 5:45	1.50	51.87
6/6/2010 6:00	1.49	51.32
6/6/2010 6:15	1.48	50.78
6/6/2010 6:30	1.48	50.78
6/6/2010 6:45	1.46	49.70
6/6/2010 7:00	1.46	49.70
6/6/2010 7:15	1.45	49.16
6/6/2010 7:30	1.44	48.63
6/6/2010 7:45	1.43	48.10
6/6/2010 8:00	1.42	47.57
6/6/2010 8:15	1.41	47.04
6/6/2010 8:30	1.41	47.04
6/6/2010 8:45	1.41	47.04
6/6/2010 9:00	1.41	47.04
6/6/2010 9:15	1.40	46.51
6/6/2010 9:30	1.40	46.51
6/6/2010 9:45	1.39	45.99
6/6/2010 10:00	1.38	45.47
6/6/2010 10:15	1.39	45.99
6/6/2010 10:30	1.39	45.99
6/6/2010 10:45	1.39	45.99
6/6/2010 11:00	1.39	45.99
6/6/2010 11:15	1.40	46.51
6/6/2010 11:30	1.41	47.04
6/6/2010 11:45	1.41	47.04
6/6/2010 12:00	1.43	48.10
6/6/2010 12:15	1.45	49.16
6/6/2010 12:30	1.47	50.24
6/6/2010 12:45	1.49	51.32
6/6/2010 13:00	1.50	51.87
6/6/2010 13:15	1.53	53.52
6/6/2010 13:30	1.55	54.63
6/6/2010 13:45	1.57	55.76
6/6/2010 14:00	1.60	57.46
6/6/2010 14:15	1.63	59.18
6/6/2010 14:30	1.66	60.92
6/6/2010 14:45	1.70	63.27
6/6/2010 15:00	1.72	64.46

Date Time	Stage (ft)	Discharge (cfs)
6/6/2010 15:30	1.78	68.09
6/6/2010 15:45	1.81	69.93
6/6/2010 16:00	1.84	71.79
6/6/2010 16:15	1.83	71.17
6/6/2010 16:30	1.85	72.42
6/6/2010 16:45	1.88	74.31
6/6/2010 17:00	1.91	76.22
6/6/2010 17:15	1.93	77.50
6/6/2010 17:30	1.94	78.15
6/6/2010 17:45	1.97	80.10
6/6/2010 18:00	1.99	81.41
6/6/2010 18:15	2.01	82.73
6/6/2010 18:30	2.04	84.72
6/6/2010 18:45	2.05	85.39
6/6/2010 19:00	2.05	85.39
6/6/2010 19:15	2.06	86.06
6/6/2010 19:30	2.05	85.39
6/6/2010 19:45	2.05	85.39
6/6/2010 20:00	2.04	84.72
6/6/2010 20:15	2.01	82.73
6/6/2010 20:30	2.00	82.06
6/6/2010 20:45	1.97	80.10
6/6/2010 21:00	1.94	78.15
6/6/2010 21:15	1.92	76.86
6/6/2010 21:30	1.90	75.58
6/6/2010 21:45	1.88	74.31
6/6/2010 22:00	1.83	71.17
6/6/2010 22:15	1.83	71.17
6/6/2010 22:30	1.81	69.93
6/6/2010 22:45	1.80	69.31
6/6/2010 23:00	1.79	68.70
6/6/2010 23:15	1.78	68.09
6/6/2010 23:30	1.76	66.87
6/6/2010 23:45	1.74	65.66

The following are the documented instantaneous flows as reported in the 2010 Annual Operating Plan.

Appendix D (9 of 15)
No Name Creek Feeder Conduit near Norrie, CO
Water Year 2010
Unit: Cubic Feet Per Second
Source: U.S. Bureau of Reclamation

Day	April	May	June	July	August	September
1			46	4		
2			40			
3			37			
4			48			
5			57			
6			62			
7			16			
8			1			
9			42			
10			15			
11			18			
12			37			
13			37			
14			29			
15			22			
16			23			
17			23			
18			21			
19			20			
20			19			
21	3	12	17			
22	5	24	14			
23		32	12			
24		34	10			
25		24	9			
26		39	9			
27		47	7			
28		25	5			
29		33	4			
30		48	4			
31		50				
Total	8	368	704	4		
Mean	4	33	23	4		
Max	5	50	62	4		
Min	3	12	1	4		
Acre-Feet	16	730	1396	8		

Water year total: 2,150 acre-feet
Maximum instantaneous peak: 86 cubic feet per second – June 6
Note: All blank spaces, recorder was not operated; no water was diverted

Appendix D (15 of 15)
Fryingpan River Feeder Conduit near Norrie, CO
Water Year 2010
Unit: Cubic Feet Per Second
Source: U.S. Bureau of Reclamation

Day	April	May	June	July	August	September
1			190	61		
2			158	44	19	
3			145	35	38	
4			183	31	32	
5			278	21	35	
6			314	13	31	
7			318	10	25	
8			291	8	23	
9			276	7	21	
10		7	251	4	7	
11		5	198	2		
12		4	175	1		
13		2	151	2		
14		3	121	2		
15		8	101			
16		8	106			
17		16	101			
18		24	75			
19		24	72			
20	3	27	68			
21	12	49	58			
22	16	70	44			
23	11	93	26			
24	5	85	23			
25	3	67	11			
26	2	96				
27	1	141				
28	2	193				
29	2	223				
30	1	207	7			
31		193				
Total	58	1545	3741	241	231	
Mean	5	70	144	17	26	
Max	16	223	318	61	38	
Min	1	2	7	1	7	
Acre-Feet	115	3065	7420	478	458	

Water year total : 11,536 acre-feet
Maximum instantaneous peak: 406 cubic feet per second – June 6
Note: All blank spaces, recorder was not operated; no water was diverted.